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VERIFICATION TESTING OF AN AH-1S WIRE STRIKE PROTECTION SYSTEM (WSPS)

LeRoy T. Burrows

December 1982

APPLIED TECHNOLOGY LABORATORY
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In-flight wire strikes pose a serious threat to low level helicopter operations. Under the sponsorship of the COBRA Project Manager and the Directorate for Systems Engineering and Development, US Army Aviation Research and Development Command (AVRADCOM) Headquarters, the Applied Technology Laboratory conducted developmental and performance verification tests to determine the suitability for AH-1S application of a Wire Strike Protection System (WSPS) designed and fabricated by Bristol Aerospace Limited and Bell Helicopter Textron, Inc. The WSPS tested consisted of an upper cutter, a telescopic sight [illegible]ector, a chin cutter above

Block 20. Abstract - continued.

the 20mm gun, a lower cutter, and a forward windshield deflector. Using the NASA-Langley Research Center's Impact Dynamics Research Facility, an AH-1S helicopter fitted with the WSPS was subjected to pendulum swing tests into the objective wire, which is a steel, seven-strand, 3/8-inch-diameter cable having an 11,500-pound tensile strength. The WSPS successfully demonstrated its capability to sever the objective wire in all tests, during which impact velocity, impact angle, aircraft pitch attitude, and aircraft impact area were varied. During the WSPS installation it was determined that some WSPS components were not necessary, and these were excluded from the system tested. During the test program it was concluded that a small cutter should be added to the system to prevent a wire from hanging up on the air data sensor boom; however, timing did not permit the fabrication and test of such a component. Acquisition and installation of the WSPS tested (modified to include an air data boom cutter) is recommended for the Army AH-1S helicopter fleet.

PREFACE

The project engineer for the tests described herein was LeRoy T. Burrows, Aerospace Engineer, Safety and Survivability Technical Area, Aeronautical Systems Division, Applied Technology Laboratory (ATL). The lead aerospace technician was Paul Triplett, also of ATL.

The author extends his gratitude to the following organizations for the support specified:

- NASA-Langley Research Center (LRC) for providing facility support, conducting the pendulum swings of the aircraft, and providing external photography.

- Directorate for Systems Engineering and Development, HQ, AVRADCOM and the COBRA Project Manager for requesting and funding these tests and for providing the test vehicle and the WSPS.

- US Army Communications Command Detachment, Fort Eustis, for timely erection of the wires for these tests.

- US Army Transportation Center and Fort Eustis for lending some test vehicle components and moving the aircraft.

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INTRODUCTION

In-flight wire strikes are a serious threat during all-weather daytime and nighttime helicopter operations, including:

- Terrain flight (nap-of-the-earth, low-level, and contour)
- Enclosed area takeoff and landing
- Confined area maneuvering

The US Army's growing emphasis on these operations is a major reason for the recent increase in the number of wire strikes experienced. Despite concentrated training in how to avoid wire strikes, and actions such as mapping wires in training areas, removing unnecessary wires, marking cables with orange spheres or other devices, and preparing SOP's to increase pilot awareness of the wire strike threat, the peacetime wire strike problem remains serious. During the period 1 January 1974 to 1 January 1980, wire strikes accounted for 8 percent of total Army aircraft damage, 6 percent of all Army aircraft injuries, and 16 percent of Army aviation fatalities. During this period none of the fatalities were caused by the main or tail rotor blades striking wires, which indicates that fuselage and skid gear strikes are the primary problem. Since many of these mishaps have occurred during training over familiar sites, it can be assumed that the wire impact threat posed by combat operations in unfamiliar areas would result in increased wire strikes. Furthermore, in a hostile environment the enemy can be expected to string wires as an intrusion countermeasure.

Since the emphasized operations require flight close to the ground during varying degrees of visibility, the hazards presented by wires and other obstacles cannot be eliminated. However, these hazards can be effectively reduced by configuring the helicopter system to be more tolerant of them. Increasing helicopter survivability to the wire strike threat will result in fewer mishaps, and therefore, increased aircraft availability, decreased maintenance, reduced casualties, and improved mission effectiveness.

A simple, cost-effective design approach to providing protection from the wire strike threat is a helicopter Wire Strike Protection System (WSPS) consisting of a combination of deflectors and passive cutters. An examination of electric power and telephone lines in use revealed that a 3/8-inch-diameter, seven-strand steel messenger cable with a tensile strength in excess of 10,000 pounds was the toughest cable found in abundance; this cable has been the cause of many fatal helicopter accidents. Accordingly, the WSPS should be designed to counter the threat of this cable, which in this report is designated the design objective wire. This wire is normally used to support heavy communications cables that contain many copper wires within.

In May 1979, a WSPS designed by Bristol Aerospace Limited (BAL) was qualified for Canadian KIOWA helicopter (OH-58A) application. This system consisted of an upper cutter, a lower cutter, and a windshield center-post deflector. BAL conducted a series of 52 wire-cutting tests by mounting a deflector and upper cutter on a wrecked KIOWA fuselage, rigidly securing this to the flatbed of a truck, and driving the truck into fixed wires. Test variables included speed (15 to 60 mph), yaw angle (0 to 45 deg), strike location (nose to top of cutter), and wires (steel-reinforced aluminum, messenger, and guy cables). Concurrently, the Canadian Aerospace Engineering Test Establishment conducted a flying qualities and electromagnetic interference (EMI) qualification of the OH-58A with the WSPS installed. All wire-cutting tests were successful, and no significant effects upon aircraft flying qualities or EMI were noted.

The wire-cutting test method employed by BAL validated upper cutter and deflector design objectives but did not test the lower cutter. Neither were questions answered regarding aircraft pitch and yaw attitude changes or deceleration loads attendant to the wire impact and cutting sequence, or their potential effects upon aircraft control and rotor blade flapping. These questions were answered by OH-58A swing tests conducted by ATL in October 1979 and reported in Reference 1. The wire impact/deflection/cutting sequence did not have a significant effect on the OH-58A helicopter with respect to attitude change or impact loads, and rotor blade flapping effects were calculated to be negligible.

The UH-1 WSPS is similar in configuration to the OH-58 system. For this reason the Canadian Armed Forces procured a WSPS for their IROQUOIS (UH-1) fleet without subjecting it to verification testing. Prior to the application of the WSPS to the US Army's UH-1 fleet, ATL was requested to conduct verification swing testing similar to that done for the OH-58 WSPS. One difference was a test where the wire was impacted at an angle of 30 degrees from the normal to the flight path, which identified the need for a windshield wiper shaft deflector as part of the WSPS. The results of the UH-1 WSPS test effort are reported in Reference 2.

The AH-1S COBRA WSPS is more complex than the OH-58 or UH-1 WSPS because of the weapons and other equipment installed on this aircraft which present potential wire snags. The AH-1S WSPS was jointly designed by Bell Helicopter Textron (BHT) and BAL under a HQ, AVRADCOM contract with BHT.

At the invitation of HQ, AVRADCOM, ATL became involved with this WSPS early in its design cycle. A recommended location for the upper cutter above the pilot station on the aircraft centerline was not considered feasible by some Army elements due to the potential adverse effect on FM homing, ADF antenna, and airborne laser tracker (ALT) performance. Accordingly, ATL requested that the US Army Aviation Development Test Activity conduct design support flight tests to determine if adverse effects did result from the proposed upper cutter location. For the AH-1S flight tests, BHT provided a mounting plate and ATL provided a modified OH-58A prototype upper cutter to simulate an AH-1S upper cutter mass. The results of the flight tests indicated that the proposed upper cutter location had a negligible effect on FM homing but did induce a significant error in the AN/ARN-89B ADF direction-finding capability. However, sufficient compensation was available in the receiver to correct the error and provide a usable system.

The US Army Night Vision and Electro-Optics Laboratory, which has responsibility for ALT development, was contacted. They conducted an analysis of the proposed upper cutter location and concluded that there would be "no significant interference with ALT operations despite minimal obscuration."

Prior to the application of the WSPS to the US Army's AH-1S fleet, HQ, AVRADCOM and the COBRA Project Manager requested that ATL conduct verification swing testing of the system. This report describes the AH-1S WSPS test effort.

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[1] LeRoy T. Burrows, *Investigation of Helicopter Wire Strike Protection Concepts*, USAAVRADCOM TM 80-D-7, Applied Technology Laboratory, US Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, June 1980, AD A086857.

[2] LeRoy T. Burrows, *Verification Testing of a UH-1 Wire Strike Protection System (WSPS)*, USAAVRADCOM TR 82-D-35, Applied Technology Laboratory, US Army Research and Technology Laboratories (AVRADCOM), Fort Eustis, Virginia, October 1982.

TEST PURPOSE

The primary purpose of this test series was to determine the suitability of the BAL/BHT WSPS for application to the AH-1S COBRA helicopter. This was to be accomplished by the experimental evaluation of each WSPS component. In addition, installation problems, potential system limitations, and airframe damage from the wire impact/deflection/cutting sequence were to be assessed.

TEST FACILITY

The AH-1S WSPS test was performed at the NASA-Langley Research Center's Impact Dynamics Research Facility shown in Figure 1. The basic structure of the facility is the 220-foot-high by 400-foot-long gantry. It is supported by three sets of inclined legs spread 267 feet apart at the ground level and 67 feet apart at the 218-foot level. A movable bridge spans the gantry at the 218-foot level and traverses the length of the gantry. A control room and an observation room are located in the building at the base of the gantry. Along the centerline of the gantry, at ground level, is a strip of reinforced concrete 400 feet long, 30 feet wide, and 0.67 foot thick.

The apparatus necessary to conduct a helicopter pendulum swing test is shown in Figure 2. Swing-cable pivot-point platforms located at the west end of the gantry supported the winches, sheaves, and pulley systems that controlled the length of the two swing cables. A pullback platform attached to the underside of the movable carriage supported the winch, sheave, and pulley system that controlled the length of the pullback cable. The swing cables were attached to an I-beam spreader bar (Figure 3) that was connected to the helicopter rotor hub and during the pendulum swing, supported the helicopter through the rotor mast, as in free flight. A pullback cable with an electrically operated hook was attached to a specially fabricated fixture placed on the aft end of the tail boom. The I-beam spreader bar was employed to prevent the test aircraft from spinning after the swing test and twisting the swing cables.

Both swing and pullback cables can be varied in length to provide desired pendulum swing arc and velocity.

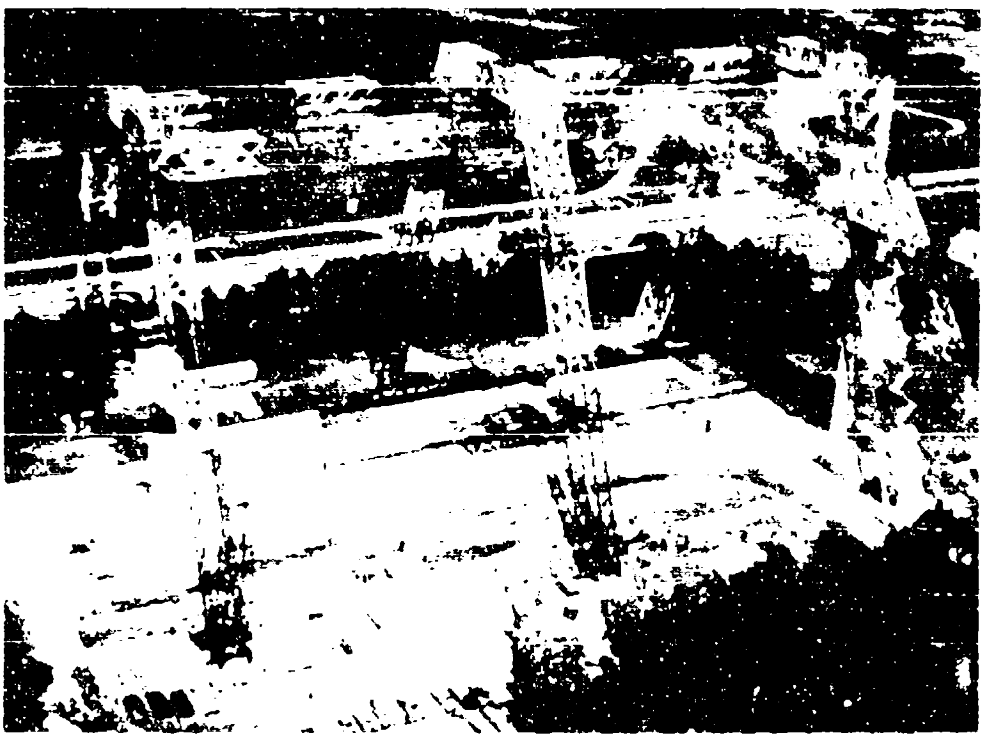

Figure 1. Impact Dynamics Research Facility.

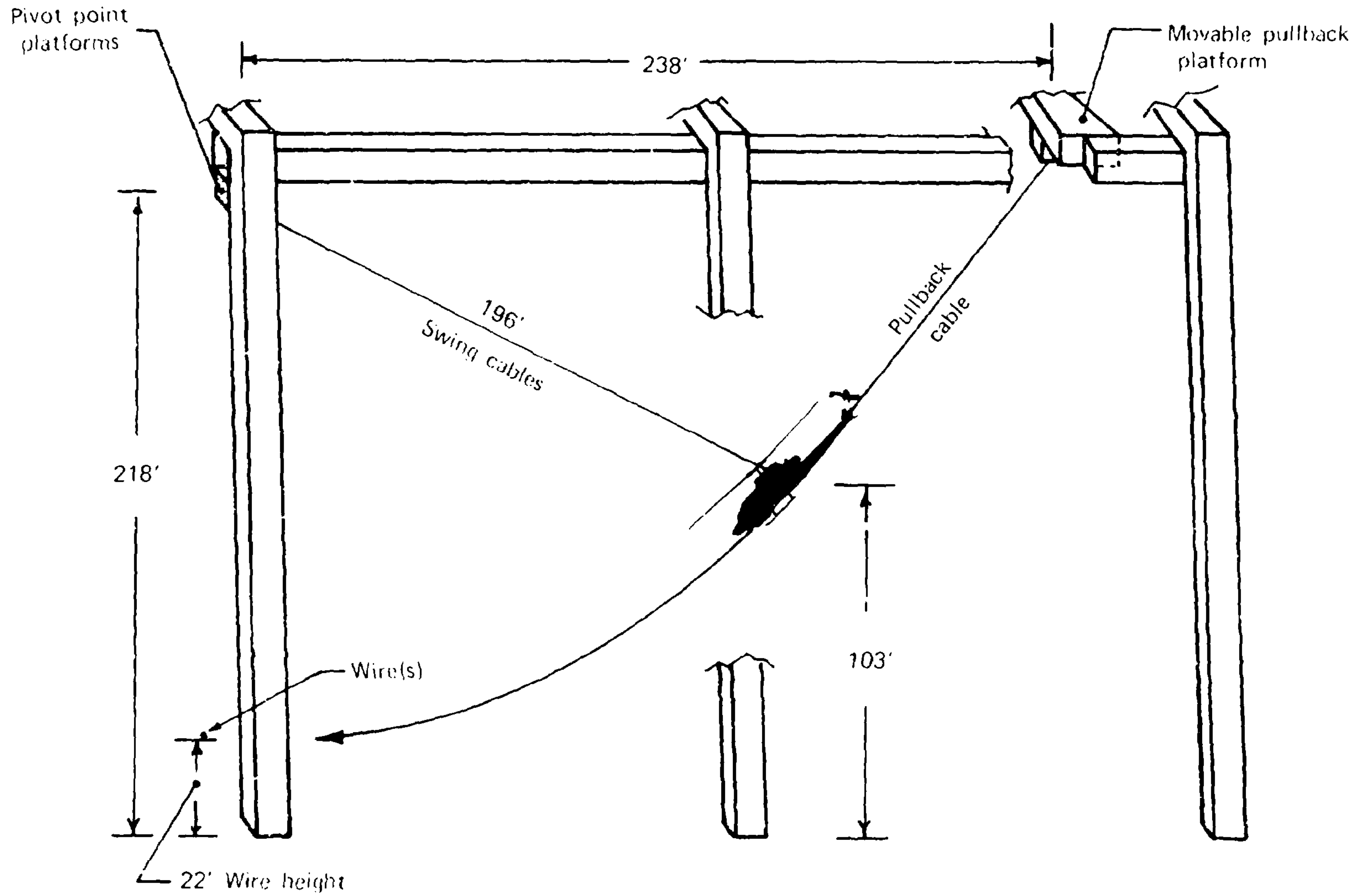

Figure 2. Pendulum swing test apparatus.

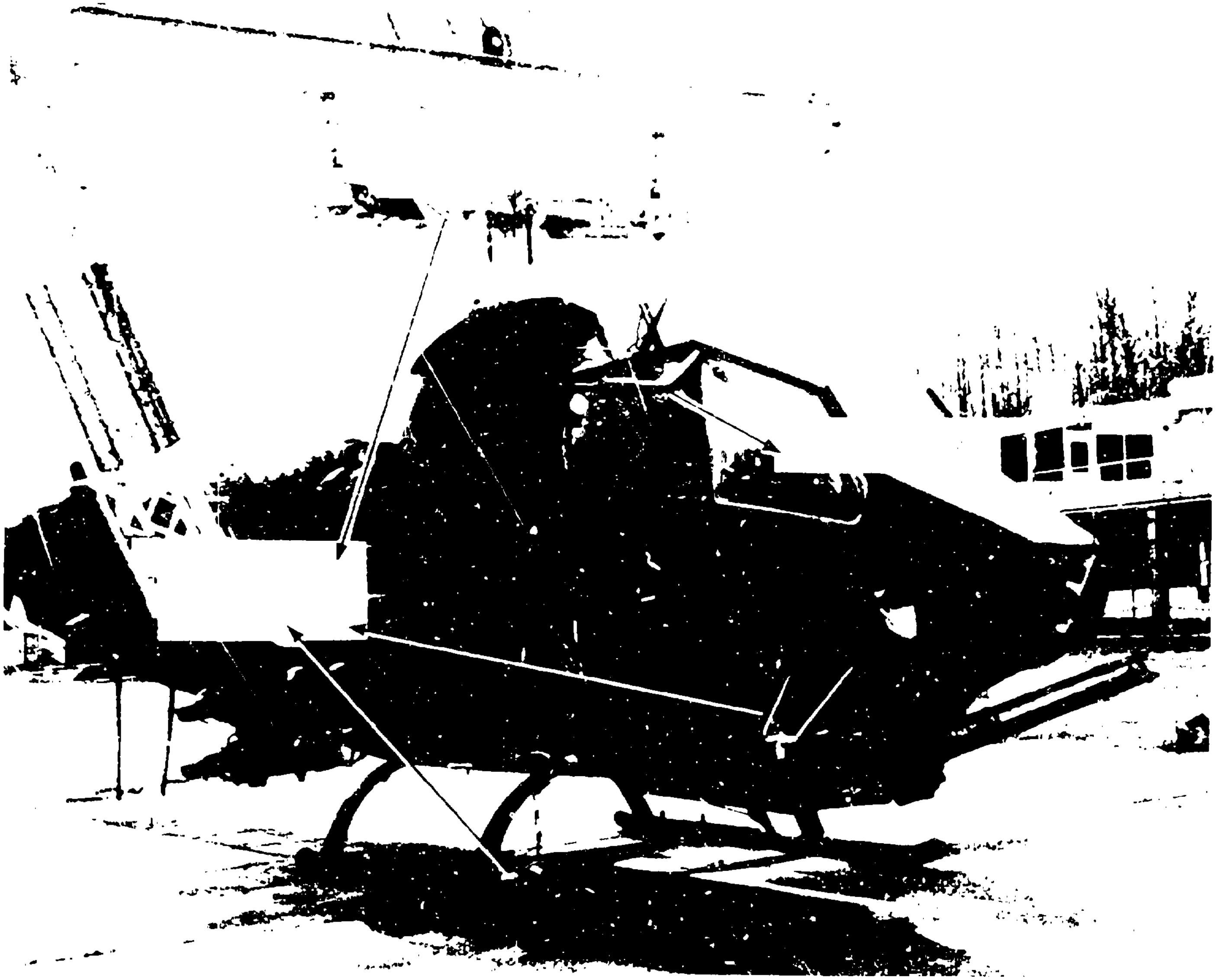

Figure 3. Test aircraft.

TEST SETUP

AIRCRAFT PREPARATION

The test helicopter was a nonflyable AH-1S (modernized COBRA), SN 76-22600, that was furnished to ATL by the COBRA Project Manager. It was fully equipped less avionic equipment, 20mm cannon, telescopic sight unit (TSU), and air data sensor. The aircraft required some rebuild after shipment, and this was accomplished by the US Army Transportation School. They also loaned to ATL and installed a TSU and a 20mm cannon. The aircraft was initially prepared for testing at the ATL research support area as follows:

1. Installed the AH-1S WSPS.
2. Fabricated and installed fixtures to prevent rotor head movement in any direction.
3. Fabricated and installed four on-board camera mounts and the circuitry and fixtures required to actuate the cameras via a lanyard.
4. Added fixtures for swing and pullback cable attachment (Figure 4).
5. Designed, fabricated, and installed a spoiler attachment to the vertical stabilizer to prevent adverse yawing during the swing tests (Figure 4).
6. Calculated weight and balance and added ballast required to place the center of gravity (cg) at the rotor mast station.
7. Added fixture to prevent TSU rotation.
8. Fabricated a dummy air data sensor.

During installation of the WSPS on the test vehicle, it was concluded that the nose shield was not required since the aircraft skin in this area was considered to be structurally capable of withstanding wire impact and deflection. It was also decided that the left forward windshield deflector with a sawtooth edge insert was not necessary and would impede wire deflection. In addition, it was determined that the two lower cutter mounting castings added excessive difficulty to the installation and could be eliminated through a simple installation procedure. HQ, AVRADCOM and the WSPS contractor, BHT, concurred with ATL's recommendation to eliminate these components from the AH-1S WSPS to be tested.

The initial weight and balance yielded a net aircraft weight of 5730 pounds with the cg at station 202, just 2 inches from the rotor mast, station 200. Seventy pounds of ballast was placed on the gunner seat floor and the rocket pod stores were added, bringing the movement weight up to 6044 pounds with the cg at the rotor mast, station 200.

A CH-47 helicopter was used to transport the test vehicle from Fort Eustis to the test site (Figure 5).

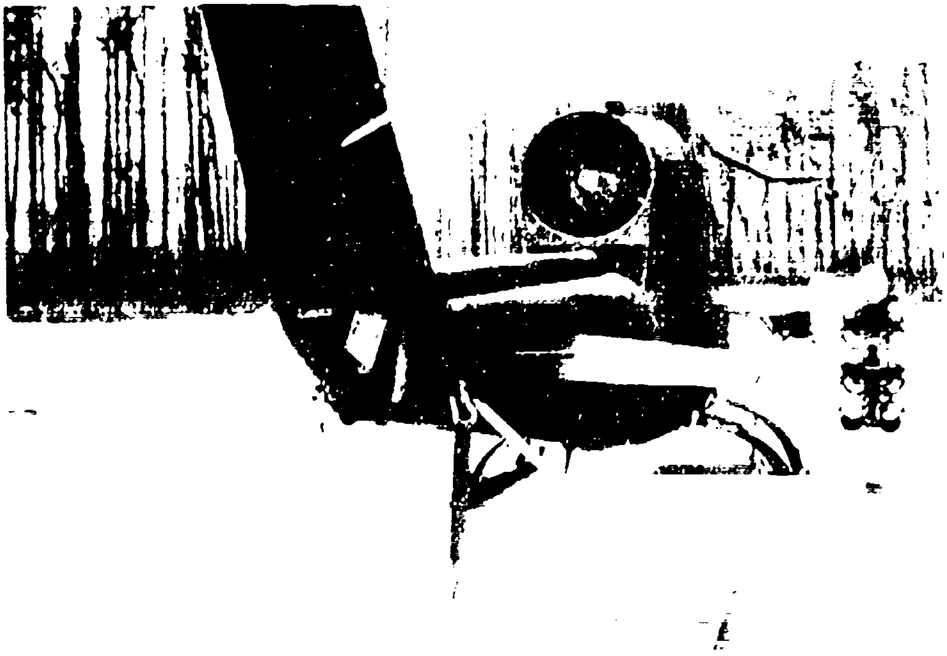

Figure 4. Test aircraft fixtures.

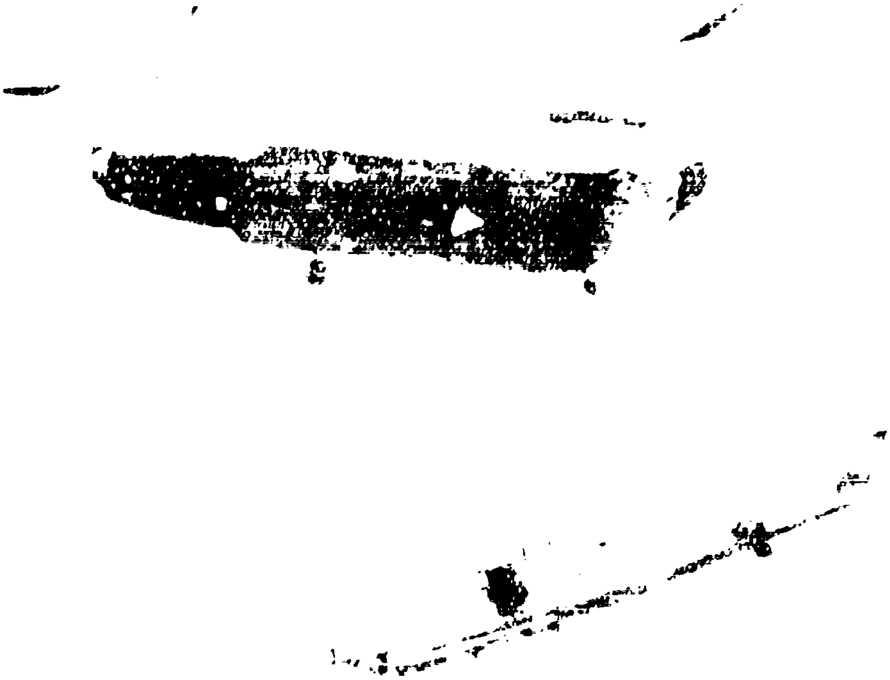

Figure 5. CH-47 transport of AH-1S.

WIRE STRIKE PROTECTION SYSTEM (WSPS)

The AH-1S WSPS tested has five major components: the upper cutter, which protects the main rotor controls (Figure 6); the TSU deflector, which prevents a wire from snagging on the TSU optics or supporting structure (Figure 7); the chin cutter, which helps prevent a wire from snagging on the 20mm cannon turret (Figure 8); a lower cutter to protect the skid gear (Figure 9); and a deflector with a sawtooth edge insert mounted on the right forward wind shield structure to provide some protection from an air data boom wire snag (Figure 10).

The WSPS is a passive system, having no moving parts. Upon wire impact, the helicopter momentum deflects the wire or cable into the upper, chin, or lower wedge-shaped cutter, which notches it to the extent required for tensile failure.

The weight of the AH-1S WSPS tested was approximately 25 pounds.

Figure 6. Upper cutter.

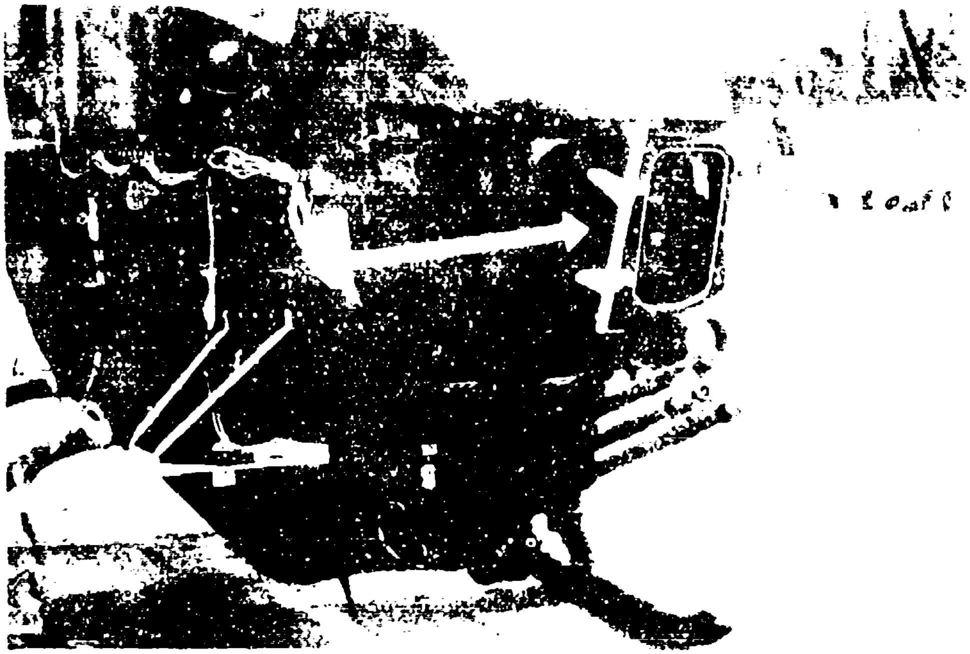

Figure 7. TSU deflector.

Figure 8. Chin cutter.

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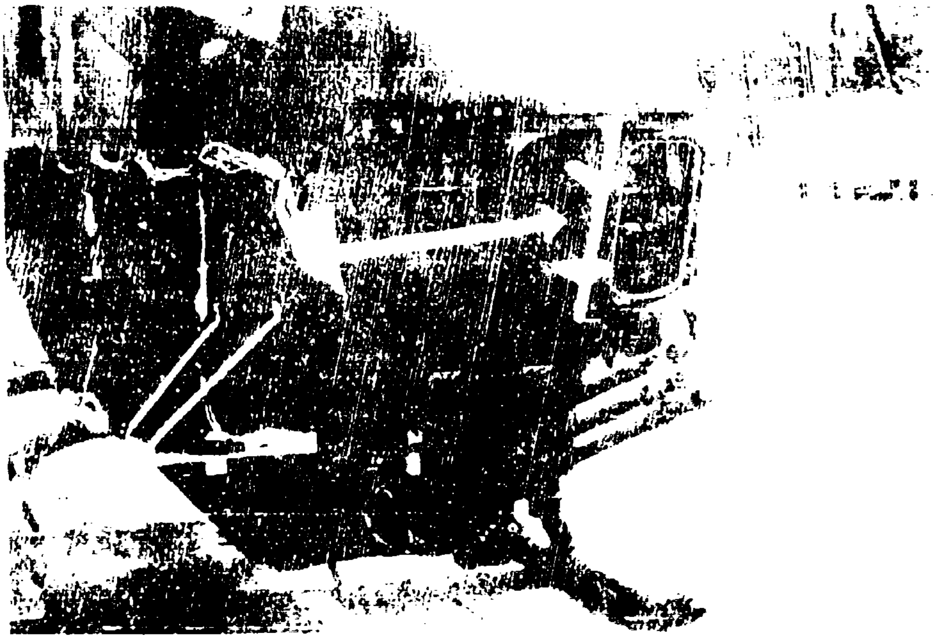

Figure 7. TSU deflector.

Figure 8. Chin cutter.

Figure 9. Lower cutter.

Figure 10. Forward windshield deflector.

OBJECTIVE WIRE

For the tests, the objective wire was a 3/8-inch-diameter, seven-strand cable having a tensile strength of 11,500 pounds. Four communication/power line poles were erected at the test site approximately 200 feet apart to permit stringing the wires 30 degrees from the normal or normal to the predicted aircraft flight path. Use of a 200-foot wire strung at a standard height and tensioned by the line crew in accordance with normal procedures provided the basis for a realistic wire installation. The wire was strung approximately 10 feet forward of the swing cable pivot-point platforms at a height of 22 feet above ground level. This permitted raising or lowering the aircraft to a pre-pullback position without wire interference.

PHOTOGRAPHIC AND RADAR COVERAGE

Mounts for four high-speed (400 frames/sec) 16mm motion picture cameras were installed on the test helicopter. One mount was placed in the cockpit to provide a pilot's eye view during the tests. The other mounts were placed to permit views of the upper cutter, chin cutter, and lower cutter and were located on the rotor hub, right side of the 20mm cannon turret, and right skid landing gear, respectively (Figure 3). A 10mm wide angle lens was used with all on-board cameras because of its wide field of view and its ability to obtain visual data at close range. These cameras were powered by an on-board NiCad battery and were activated by a lanyard switch through circuitry located in the AH-1S ammunition bay (Figure 11). At the T-minus-3-seconds point of the aircraft release countdown, the lanyard pin is manually pulled, thus permitting camera run-up prior to release.

The exterior high-speed and still sequence motion picture photography was provided by NASA. Hand-held real time and rapid sequence cameras were operated by ATL photographers. Ground coverage included four high-speed (650 frames/sec) ground cameras and two 70mm still sequence (50 frames/sec) cameras.

Radar was set up by NASA personnel to measure helicopter velocity at wire impact. The radar used was a stand-mounted, continuous-wave Doppler system.

INSTRUMENTATION

A 10,000 pound-capacity load cell was installed at each end of the objective wire and then secured to the line poles. These load cells were connected to the amplifier-recorder electronics by 260- and 320-foot cables for the left and right poles, respectively. Each load cell was calibrated before and after each test. Prior to each test, the static line tension measured by the load cells was zeroed out so that only the time history of the increase in line tension during the wire impact/deflection/cutting sequence was measured.

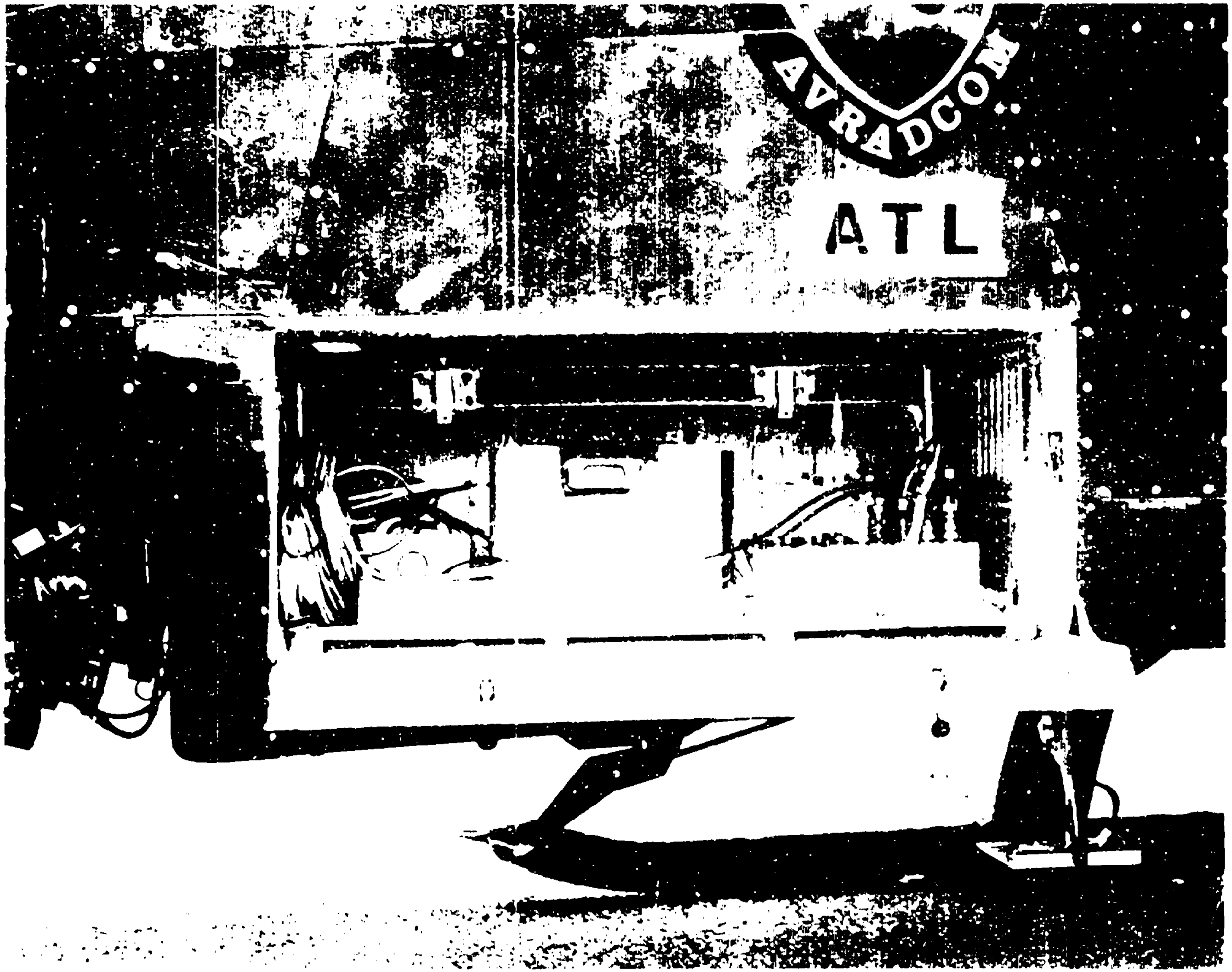

Figure 11. On-board camera circuitry.

TEST DESCRIPTION AND RESULTS

PLANNED TEST PROGRAM

The Directorate for Development and Qualification, HQ, AVRADCOM, specified a qualification test program for the AH-1S WSPS. The final coordinated test program and conditions, taking into account test rig limitations, are provided in Table 1.

Prior to initiation of the official test series, the aircraft was swung twice at a peak velocity of 40 knots without wires erected to ascertain the aircraft motion during a pendulum swing while supported only through the rotor mast. This was especially important for this test program in which pitch attitude was to be varied (Table 1) by shifting the ballast, thus moving the lateral cg away from the rotor mast station. Neither of these tests resulted in erratic flight motions and the static pitch attitude was maintained at the bottom of the pendulum swing, thus indicating that no further restraint of the aircraft during the 40-knot wire impact tests was required. The tests also indicated that the vertical stabilizer spoiler designed, fabricated, and installed by ATL was highly effective in preventing adverse aircraft yaw throughout the pendulum swing.

TABLE 1. AH-1S WSPS QUALIFICATION TEST PROGRAM CONDITIONS

Test	Objective Wire Impact Location	Impact Velocity (kt)	Wire Angle With Respect to Flight Path	Pitch Attitude
A	Nose structure above TSU	40	Normal	5 to 10 deg nose down
B	Forward windshield	40	25 to 30 deg from normal	5 to 10 deg nose down
C	TSU deflector	15	Normal	5 to 10 deg nose up
D	Tip of lower cutter	40	Normal	+3 to -3 deg

ACTUAL TEST PROGRAM

For each test, the AH-1S aircraft was lifted by the two swing cables to a height that would provide the desired location of initial wire impact. In estimating lift height or swing cable length needed to obtain the desired impact location, swing cable elongation under dynamic loads must be considered. For a 40-knot swing test, the vehicle will pull approximately 1 G additional acceleration at the base of the swing; for the size swing cables used, this equates to an elongation of approximately 5 inches. The swing cables were attached to the rotor hub by a ring attachment that allowed pitching movement of the aircraft independent of the swing cables. The pullback height was calculated to provide a pendulum swing flight path that would result in the desired aircraft velocity at wire impact.

The actual test program is shown in Table 2. The planned tests A, B, C, and D specified in Table 1 should be compared directly to the actual tests 1, 2, 5, and 6, respectively. Due to

facility restrictions, the wire poles had to be erected such that the objective wire was impacted much closer to the left pole than to the right pole. Therefore, test discussion is limited to left pole load cell data which is more indicative of the wire impact/deflection/cutting sequence events. For each test, pitch attitude was varied by shifting the lead ballast to obtain a static pitch attitude consistent with the test plan specified in Table 1. A description of each actual test follows

TABLE 2. AH-1S VERIFICATION TESTING CONDUCTED

Test No.	Date	Wire Impact Location	WSPS Component Tested	Wire Angle From Normal (deg)	Velocity at Impact (kt)	Increase in Wire T (lb) Left Pole	Right Pole	[illegible]
1	4/15/82	Nose above TSU deflector	Upper cutter	0	40.1	3762	3392	-6
2	4/19/82	Forward windshield	Upper cutter	30	39.5	3018	2836	-6
3	4/20/82	Chin cutter	Chin cutter	0	17.8	4083	3392	+8
4	4/21/82	Above chin cutter	Chin cutter	0	17.9	3466	3055	+8
5	4/21/82	TSU deflector	TSU deflector and chin cutter	0	17.8	3390	2020	+8
6	4/22/82	Lower cutter	Lower cutter	0	33.4	3416	1961	0

Test 1

To obtain a 6-degree nose-down pitch attitude, 350 pounds of ballast was added to the floor of the gunner's seat. The pullback position for the 40-knot test is shown in Figure 12. The wire impact was to be on the aircraft nose after getting by the TSU position indicator, which is a metal rod sticking up approximately 6 inches above the front of the TSU. In this test the wire impacted the TSU position indicator rod, bent it over, and then impacted the aircraft nose. The wire deflected upward to the forward windshield deflector where it gouged out teeth from the sawtoothed blade insert in three places, progressively notching the wire until it broke in tension near the top of the deflector. The left pole wire tension time history given in Figure 13 graphically depicts these events.

To better understand this and like figures from subsequent tests, Figure 13 is explained as follows. Initial impact loading is shown followed by a tension decrease as the wire bounced from the TSU indicator to the nose structure and into the deflector sawtooth edge where a temporary snag provided a steep tension increase. This continued until the wire broke loose of the snag, decreasing tension, and bounced to another area of the deflector with an attendant snag and tension increase. This sequence of events took place one more time, and the wire eventually broke. It should be noted that, even if there are no snags, while the wire is in contact with the aircraft wire tension will increase due to deflection friction and small obstructions, such as screw and bolt heads, and due to the taking up of static slack in the wire.

The on-board cameras used during this test were mounted in the cockpit and on the rotor hub. Figure 14 shows the bent TSU position indicator rod, while Figure 15 shows the area where the aircraft skin was scraped and cracked.

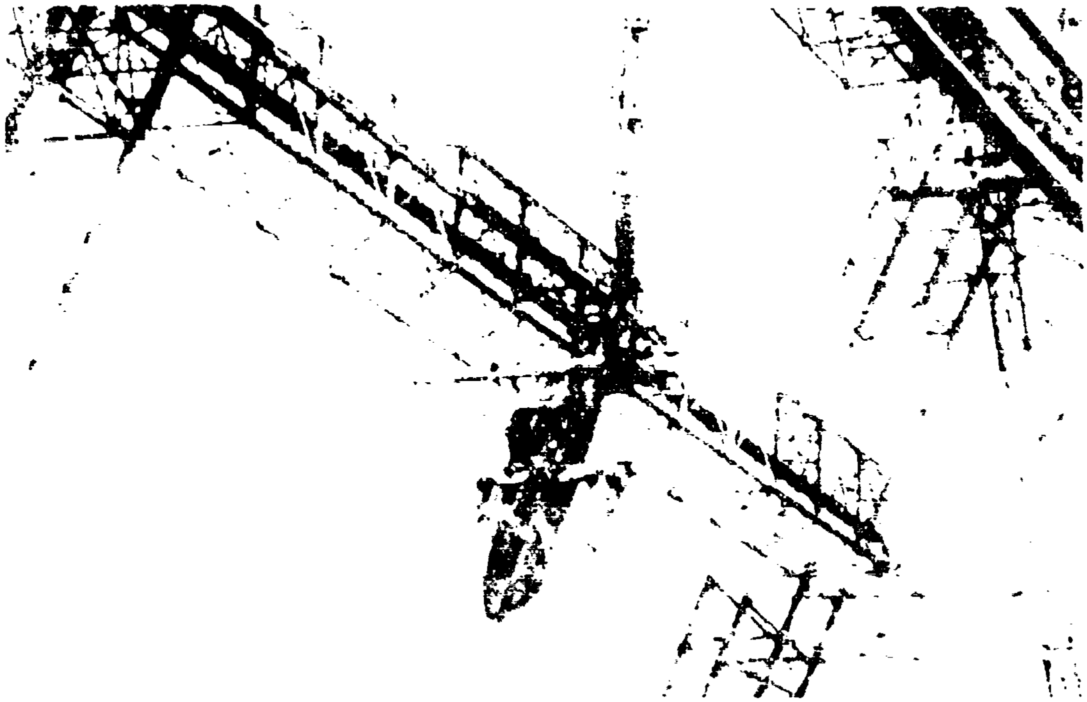

Figure 12. 40-knot test pullback position.

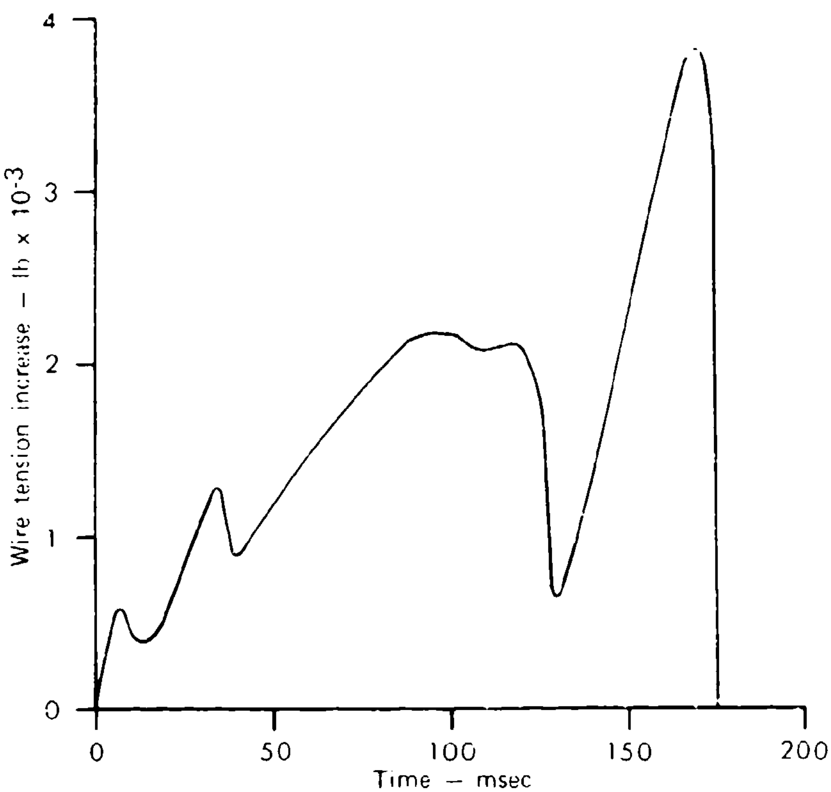

Figure 13. Test 1 wire tension time history.

Figure 14. Test 1 effect on TSU position indicator.

Figure 15. Test 1 effect on nose skin.

Test 2

The wire impacted about halfway up the forward windshield structure (Figure 16) and deflected into the upper cutter where it was notched and failed in tension (Figure 17). Figure 18 depicts the wire tension time history for this angled wire test. Minor aircraft skin damage occurred at the impact point and, as the wire deflected, on the forward windshield structure (Figure 19). Analysis of the high speed motion picture documentation and Figure 18 showed that the wire stayed in contact with the forward windshield for over one-half of the impact deflection cutting sequence, and that there were minor snags on the left corner edge of the forward and upper windshield structure and the left edge of the upper cutter mounting plate all of which were amplified by the angled wire impact.

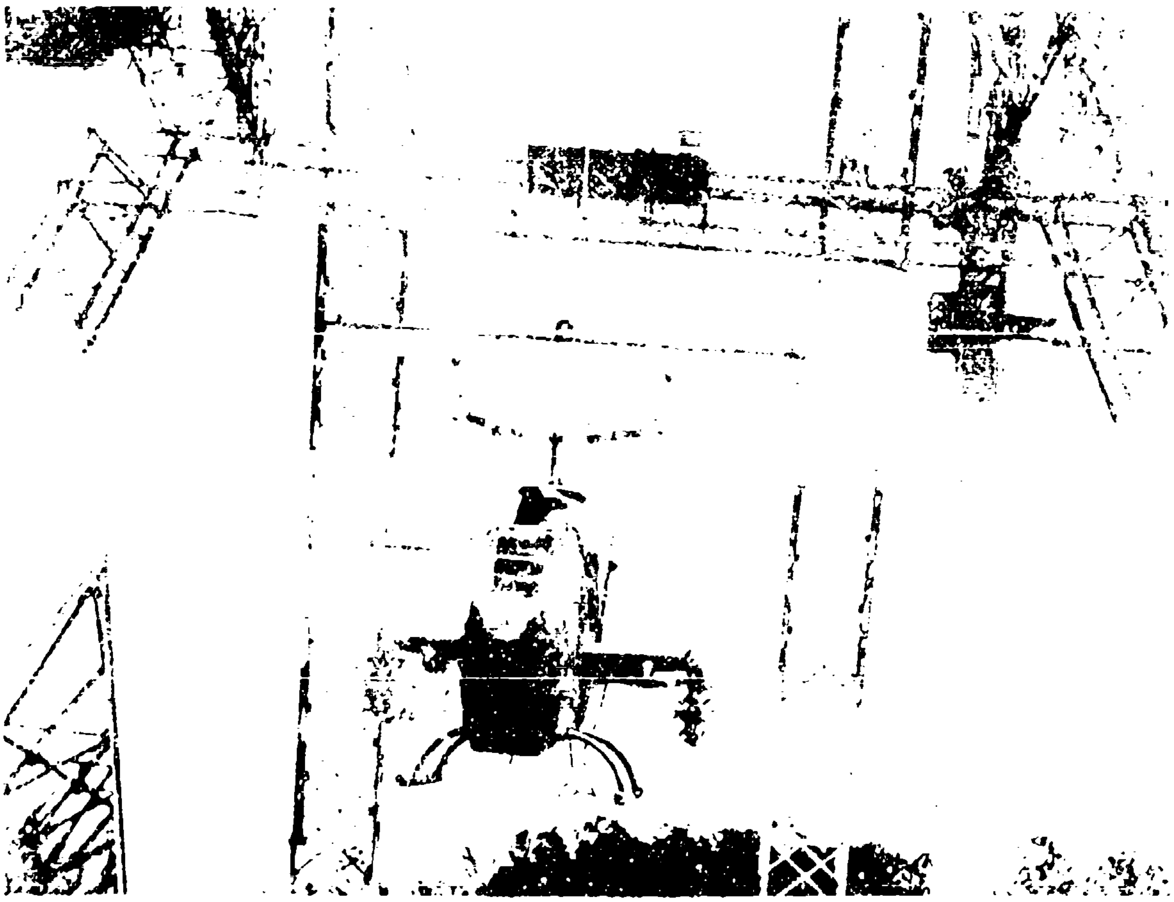

Figure 16. Test 2 wire impact.

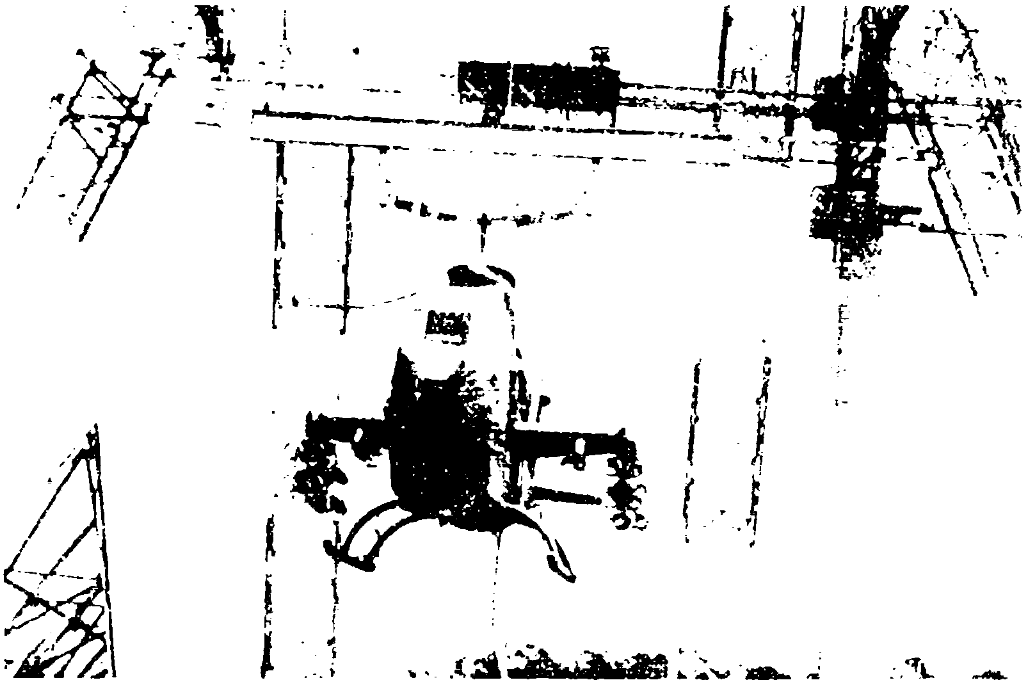

Figure 17. Test 2 wire cut.

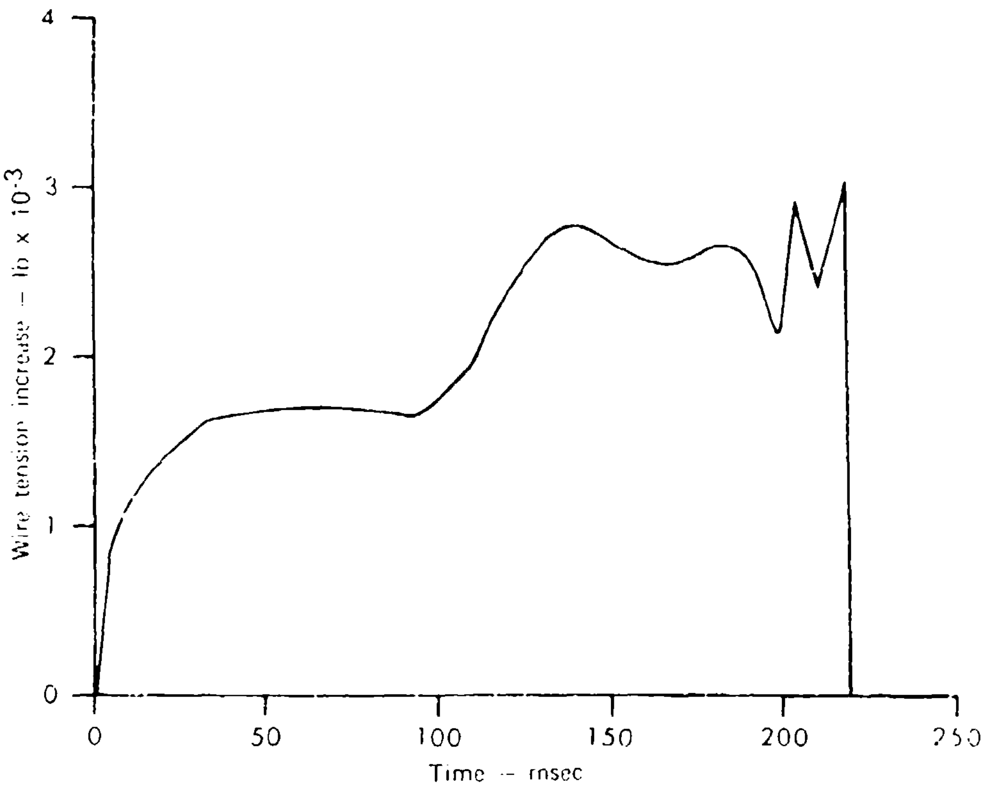

Figure 18. Test 2 wire tension time history.

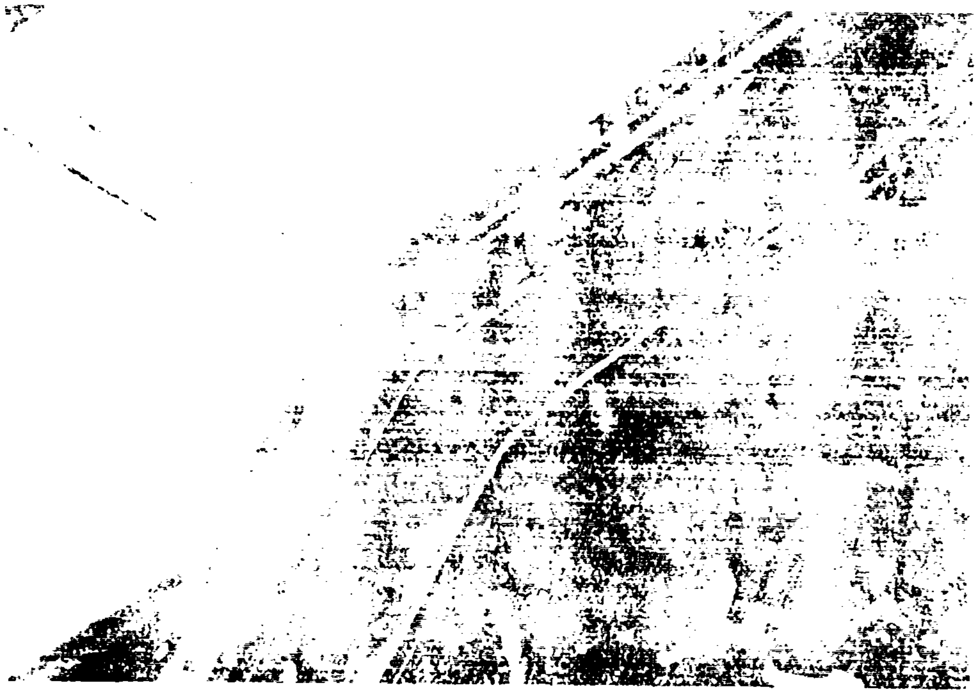

Figure 19. Test 2 aircraft damage.

Tests 3, 4, and 5

Difficulty was encountered in accomplishing planned test C (15 knot impact) described in Table 1. To obtain the nose-up attitude, ballast was shifted aft, resulting in a tail-heavy aircraft. The pullback platform had been set for the 40 knot test so that the pullback cable was in line with the aircraft cg at the release point. In a test swing without a strung wire, the tail dropped upon release and created a severe unpredictable pitch oscillation that continued throughout the swing. This was largely due to the pullback cable not being in line with the aircraft cg. Attempts to dampen this motion using various aircraft rigging concepts were unsuccessful. The pullback platform was then moved as far back as possible and the pullback cable was run down through a pulley, located on the gantry at a height of 164 feet, to the aircraft, putting the pullback cable almost in line with the aircraft cg at the 15 knot pullback height. Lines were rigged from the swing cable spreader bar to each skid at fore and aft locations to help damp out any porpoising effect. Swing tests without a wire were again conducted with much less pitch oscillation than earlier encountered. Film analysis showed the pitch variation to then be somewhat repeatable and the nose-up pitch attitude to be 8 degrees at the point where the wire would be contacted. Swing cable elongation for this test was estimated to be approximately 1 inch. The pullback position for the 15 knot test is shown in Figure 20.

In test 3 the wire struck the chin cutter instead of the TSU deflector, and a successful cut resulted.

In test 4 the TSU deflector was again missed, and the chin cutter provided another successful wire cut.

In test 5 the wire impacted the TSU deflector (Figure 21) and then deflected into the chin cutter, again resulting in a successful cut (Figure 22). Figure 23 depicts the wire tension time history for this test. Immediately after impact, the wire snagged the TSU optics protective cover mounting screw head, building up a constant tension until it released and deflected to the forward edge of the chin cutter, where it snagged momentarily before entering the cutting surfaces. The TSU structure and the cover screw head received superficial damage.

Figure 20. 15-knot test pullback position.

Figure 21. Test 5 wire impact.

Figure 22. Test 5 wire cut.

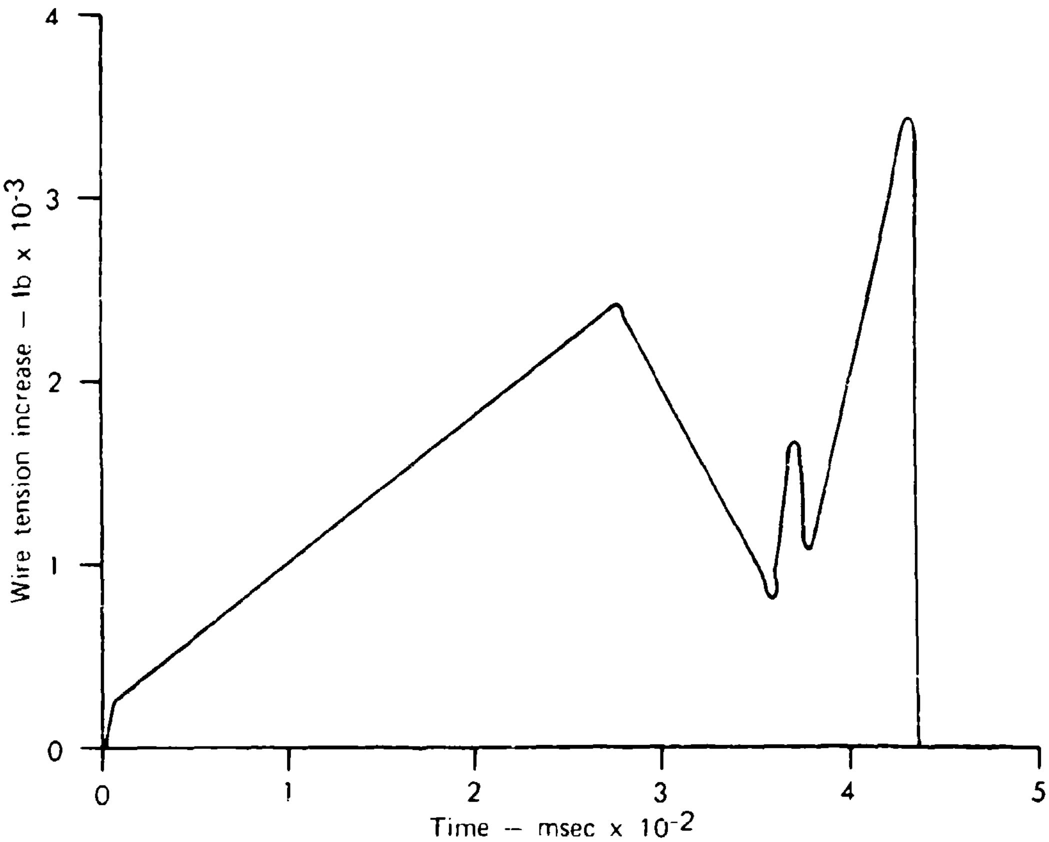

Figure 23. Test 5 wire tension time history.

Test 6

The pullback platform was moved back to the position required for a 40 knot test, and this test was successfully conducted.

Figure 24 depicts the wire tension time history. The wire impacted the lower cutter right below its joint with the lower blade insert (Figure 25). This joint proved to be a minor snag area, impeding deflection into the cutting blades. When the wire let go it entered the blades and was notched and broken (Figure 26).

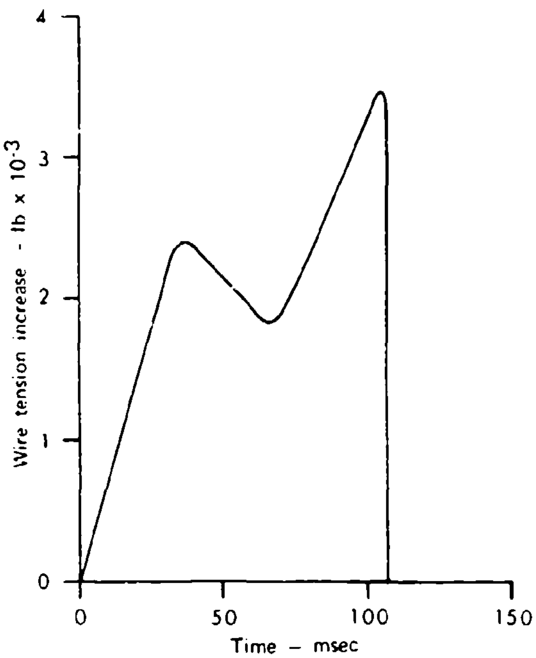

Figure 24. Test 6 wire tension time history.

Figure 25. Test 6 wire impact.

Figure 26. Test 6 wire cut.

BREAKAWAY TIP TEST

This additional test was requested by HQ, AVRADCOM and was conducted at the ATL research support area. A lower cutter breakaway tip is desirable in that it would prevent aircraft damage when the aircraft straddles a solid object upon landing. A hole was drilled into the cutter tip and a cable connected as shown in Figure 27. The cable was progressively tensioned until the shear rivet failed (Figure 28). For this test a load cell was connected to the tension line and the recorded data indicated that the rivet sheared at a 542 pound load. This is within 10 percent of the design failure load of 500 pounds.

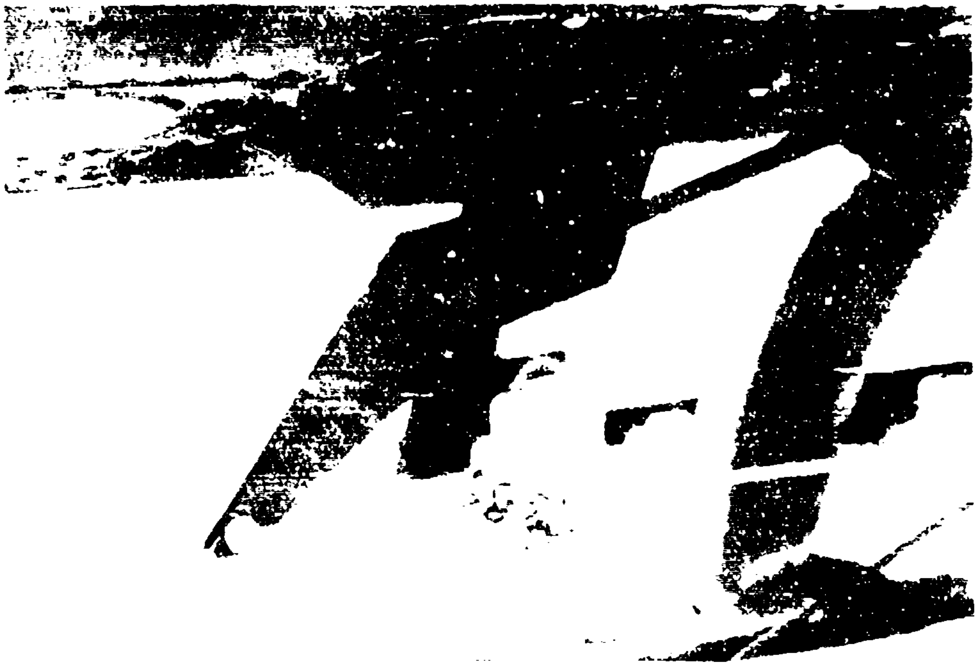

Figure 27. Breakaway tip test setup.

Figure 28. Breakaway tip test results.

ANALYSIS

Analysis of the test films, the post-test aircraft condition, and the wire tension load cell data resulted in the following observations:

1. The upper, lower, and chin cutters were all effective in notching the objective cable to the extent where it would fail in tension at a force less than one-third of its basic tensile strength.

2. The left side forward windshield deflector with a sawtooth blade insert impedes deflection and is not adequate protection from the serious danger of a wire snagging the air data boom (Figure 3). At higher wire impact velocities than that tested, unacceptable loads may be transmitted to the aircraft windshield structure as a result of the snag created when teeth are gouged out of the sawtooth blade insert.

3. The forward edges of the upper cutter mounting plate are minor snags that can be easily eliminated.

4. The lower cutter components did not provide smooth wire deflection into the cutting edges. This minor problem could be easily corrected in a production design.

5. For the low-speed test (18 kt) the wire was in contact with the test aircraft for 437 ms as compared to the 40-knot tests where the wire was in contact for 107 to 217 ms, depending upon the impact point. Any aircraft attitude variation that may occur due to wire contact loads in a 1/2-second time period would probably correct itself after wire breakage before the pilot could make a corrective control input.

CONCLUSIONS

1. The passive WSPS concept as modified and tested should be effective in protecting the AH-1S helicopter against mishaps caused by wire strikes. When the system is installed fleetwide, fewer accidents, injuries, and fatalities than are presently being experienced from wire impacts in unprotected Army helicopters should result.

2. Frame-by-frame film analysis indicates that the wire impact/deflection cutting sequence will not have a significant effect on the helicopter or the operator with respect to performance and control.

3. The wire snag potential of the air data boom presents a significant limitation to the system tested.

4. Because of the weapon systems installed on a gunship and the inability to provide full protection, the AH-1S WSPS will be less effective than those designed for the OH-58 and UH-1 helicopters.

RECOMMENDATIONS

Based on the ATL wire strike protection test series, it is recommended that:

1. The AH-1S WSPS include a cutter mounted at the joint of the air data boom and the windshield structure. Once this is done, the deflector with a sawtooth edge insert mounted on the right side of the forward windshield structure should be eliminated.

2. The Army initiate retrofit of AH-1S helicopters with a WSPS as modified above.

3. All new helicopter specifications include a requirement for a WSPS.

4. The BLACK HAWK and Advanced Attack Helicopter Project Managers take action to define a WSPS configuration suitable for those helicopters, retrofit aircraft already produced, and plan for WSPS installation during production.